

DOCUMENT RESUME

ED 285 009

CE 048 077

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TITLE Precision Optics Curriculum.
INSTITUTION Texas State Technical Inst., Amarillo.
SPONS AGENCY Texas Coll. and Univ. System, Austin. Coordinating Board.
PUB DATE 87
GRANT 87-1030-A-10
NOTE 21p.
PUB TYPE Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Competency Based Education; Lasers; *Machine Tool Operators; *Optics; Postsecondary Education; *Technical Education
IDENTIFIERS *Optical Technicians; *Precision Optics

ABSTRACT

This guide outlines the competency-based, two-year precision optics curriculum that the American Precision Optics Manufacturers Association has proposed to fill the void that it suggests will soon exist as many of the master opticians currently employed retire. The model, which closely resembles the old European apprenticeship model, calls for 300 hours of prerequisites and 1,572 hours (78 credits) of instruction over 5 quarters for a certificate or 2,280 hours (114 credits) of instruction over 7 quarters for an associate of applied science degree. An additional 360 hours (18 credits) of cooperative training may also be taken but may not replace any of the other required instruction. This guide includes an outline of the proposed program, descriptions of 37 of the recommended courses, a list of equipment required for the precision optics technology program, and a listing of tasks in 10 duty areas covered in the various recommended courses. Tasks are organized according to the following duty areas: identify optical components, identify optical devices, use geometric optics, prepare substrate, lap substrate, polish substrate, perform first-echelon preventive maintenance, perform optical testing, perform visual inspection by MIL SPEC, and explain wave optics. (MN)

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SEP 11 1987

ED285009

Precision Optics Curriculum

Developed
by:

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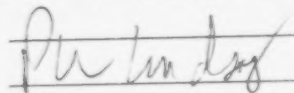
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The authors wish to express their gratitude to the following individuals and companies who assisted in this project.

Mr. Eugene Arthurs	Oriel Corporation
Mr. Ken Budd	Optic-Electronic Corp.
Mr. Steve Diggles	The Optical Corporation
Mr. Albert Efke	Hughes Optical Products Inc.
Mr. Dan Hull	Center for Occupational Research and Development
Mr. Kurt Kubath	University of Rochester Institute of Optics
Mr. Chuck Lange	Chuck Lange and Associates
Dr. Robert Leshne	Trans World Optics, Inc.
Dr. Alex Marker	Schott Glass
Mr. Claude McWhirter	Optic-Electronic Corp.
Mr. Bob Rankin	Optic-Electronic Corp.
Mr. Dave Romashko	Schott Glass
Mr. John B. Sloan	Glass Mountain Optics
Mr. Chuck Terpstra	Dimension Optics
Mr. John Thompson	Optical Associates
Mr. Gaylon Vanhose	Hughes Optical Products Inc.
Mr. Ron DeSpain	TSTI-Amarillo
Mr. Erie Johnson	TSTI-Amarillo
Mrs. Gertrude Thompson	TSTI-Amarillo

The Optics industry in the United States is at a crucial point in its history. Many of the Master Opticians currently employed are European and ready to retire. There has not been an adequate training program offered in this country which can fill the void these retirements would create. The American Precision Optics Manufacturers Association (APOMA) has instituted a training program which closely resembles the old European Apprenticeship model. Most educators feel that a two year technical program such as the one here developed will provide a more well rounded, generic optician who would be capable of becoming the Master Optician.

The curriculum developed has made use of many courses which community colleges, junior colleges and technical schools already have in place. The tasks for these courses have not been included but are available upon request. The tasks attached are for use within the optics area solely.

There are very few texts available for optical fabrication. As a result, one of the keys to an effective optical training program is the hiring of an effective teacher in the optics field. The Academician will not fulfill this position. The actual fabrication processes must be taught by someone who has the hands-on knowledge of fabrication. In other words, if possible, hire the Master Optician.

This curriculum is competency based. The student should be required to master each knowledge task to ninety percent. Each hands-on task should be on a Go/No Go basis. Further information on this technique is available from the authors.

BOOKLIST

The Photonics Design and Applications Handbook: Laurin
Publishing Co.; Pittsfield, MA.

The Photonics Dictionary: Laurin Publishing Co.; Pittsfield, MA.

Geometric and Wave Optics: CORD; Waco, TX.

Laser Electro-Optic Devices: CORD; Waco, TX.

Laser Electro-Optic Components: CORD; Waco, TX.

The Optics Problem Solver: Research and Education Association;
New York, NY.

Fundamentals of Optics: McGraw-Hill Book Company; New York, NY.

Experimental Optical Methods: CORD; Waco, TX.

Military Specifications: Department of Defense; Washington, DC.

PRECISION OPTICS TECHNOLOGY
CURRICULUM

COURSE TITLE	HOURS	CREDITS
PREREQUISITES		
Basic Communications	60	0
Introduction to Communications	48	0
Developmental Reading & Study Skills	60	0
General Math	48	0
Basic Math Measurements	24	0
Introduction to Algebra	60	0
	<u>300</u>	<u>0</u>
FIRST QUARTER		
Basic Machine Shop	60	3
Optics Seminar	60	3
	<u>120</u>	<u>6</u>
SECOND QUARTER		
*Intermediate Algebra	48	4
Blueprint Reading	60	3
*Composition I	48	4
Trigonometry I	24	1
Introduction to Precision Optics	96	3
Optical Materials	84	3
	<u>360</u>	<u>18</u>
THIRD QUARTER		
*College Algebra	48	4
Geometric Optics	84	4
Optical Testing	84	4
Basic Optical Fabrication	156	6
	<u>372</u>	<u>18</u>
FOURTH QUARTER		
*Discussion & Small Group Communication	48	4
Light Sources & Wave Optics	72	4
Intermediate Optical Fabrication	156	6
Optical Components	84	4
	<u>360</u>	<u>18</u>
*General Education Courses		

COURSE TITLE	HOURS	CREDITS
FIFTH QUARTER		
*Psychology of Adjustment	48	4
Optical Devices	96	4
Advanced Optical Fabrication	216	10
	360	18
EXIT POINT: CERTIFICATE		
SIXTH QUARTER		
Exotic Optical Materials	84	4
*Technical and Business Writing	48	4
Computer Literacy	72	4
Custom Optical Fabrication	144	6
	348	18
SEVENTH QUARTER		
Optics Project	180	8
Exotic Optical Fabrication	180	8
	360	18
EXIT POINT: ASSOCIATE OF APPLIED SCIENCE		
Optional:		
Cooperative Training	360	18
(Cooperative Training requires 5th or 6th quarter standing and is taken in addition to, not in replacement of, all required courses in the curriculum.)		
OPTIONAL COURSES		
Plane Trigonometry	48	4
Mechanics, Heat, Light and Sound	84	5
Electricity and Magnetism	84	5
Fundamentals of Physics	48	4
Computer Aided Drafting and Design I	60	3
Introduction to Lasers	142	7

*General Education Courses

PRECISION OPTICS TECHNOLOGY
COURSE DESCRIPTIONS

OPTICS SEMINAR

Hours: 60 Credits: 3

A study of the role of the optics technician, job opportunities, safety and the equipment which is used. Specific optics terminology will also be covered.

OPTICAL MATERIALS

Hours: 84 Credits: 3

Prerequisite or Corequisite: Optics Seminar

A study of the types of materials used in optical fabrication and the properties of these materials.

INTRODUCTION TO PRECISION OPTICS

Hours: 96 Credits: 3

Corequisite: Optical Materials

A study of the processes of optical fabrication. The student will make simple lenses, mirrors, etc.

BASIC OPTICAL FABRICATION

Hours: 156 Credits: 6

Prerequisite: Introduction to Precision Optics

Fabrication of optical components to the following standards. Dimensional Tolerance - ± 5000 ths; Angle - visible machinist square; Surface Quality - 80/50; Centering - 3000ths to indicator; Flatness - 1 wave.

OPTICAL COMPONENTS

Hours: 84 Credits: 4

A study of various optical components, their properties and uses. The student will identify by sight prisms, lenses, flats, mirrors, etc. and measure radii of curvature, roof angles, etc.

INTERMEDIATE OPTICAL FABRICATION

Hours: 156 Credits: 6

Prerequisites: Geometric Optics and Basic Optical Fabrication

Fabrication of optical components to the following standards. Dimensional Tolerance - ± 2000 ths; Angle - one minute; Surface Quality - 60/40; Centering - 3000ths to indicator; Flatness - $\frac{1}{2}$ wave.

OPTICAL DEVICES

Hours: 96 Credits: 4

Prerequisites: Optical Components and Light Sources & Wave Optics

A study of various optical devices to include binoculars, telescopes, periscopes, collimators, cameras, etc. Introduction to design of optical systems will be included.

ADVANCED OPTICAL FABRICATION

Hours: 216 Credits: 10

Prerequisite: Intermediate Optical Fabrication

Corequisite: Optical Devices

Fabrication of optical components and devices to the following standards. Dimensional Tolerance - $\pm 5/10,000$ ths; Angle - Exact; Surface Quality - 40/20; Centering - $\frac{1}{2}$ minute; Flatness - 1/10 wave or better.

EXOTIC OPTICAL MATERIALS

Hours: 84 Credits: 4

Prerequisite: Intermediate Optical Fabrication

A study of the exotic materials used in optical fabrication for the UV and IR. Safety in handling and working these materials will be covered as well as the wavelength ranges for which they are used.

CO-OPERATIVE TRAINING

Hours: 360 Credits: 18

Students will work a minimum of 360 hours during one quarter as an optical technician trainee and will submit weekly reports on training activities to the program chairperson. Jobs will be available on a first-come-first-serve basis. Students will be responsible for own transportation to and from the work site and own room and board. This elective course is in addition to and does not replace other courses in the curriculum. A minimum of fifth (end of fourth Quarter) or sixth quarter standing is required.

OPTICAL TESTING

Hours: 84 Credits: 4

A study of the principles of testing optical components. The use of the interferometer and other testing instruments and procedures will be covered.

CUSTOM OPTICAL FABRICATION

Hours: 144 Credits: 6

Fabrication of custom optical components. Students will be given specifications for custom components and produce the required components to standards specified by order.

OPTICS PROJECT

Hours: 180 Credits: 8

Prerequisite: Advanced Optical Fabrication

Student will select an optical device or optical components, do the basic design and then fabricate the item.

EXOTIC OPTICAL FABRICATION

Hours: 180 Credits: 8

Prerequisites: Advanced Optical Fabrication and
Exotic Optical Materials

Fabrication of optical components using exotic materials.

LIGHT SOURCES & WAVE OPTICS

Hours: 72 Credits: 4

Prerequisite: Geometric Optics

A course designed to provide the student with the basic knowledge of the principles and theory of light and its wave nature. Topics include origin of light, spectral characteristics of light, radiometry, photometry, reflection, refraction, propagation of light, interference, diffraction and polarization.

GEOMETRIC OPTICS

Hours: 84 Credits: 4

Prerequisite: Trigonometry I

A course designed to provide the student with the basic knowledge of the theory of light as a geometric ray. Application of the laws of reflection and refraction from the mathematical, the graphical, and the experimental aspects are studied.

BASIC MACHINE SHOP

Hours: 60 Credits: 3

A study of the operation of basic machine shop tools to include band saws, drill press, grinders, lathes, etc. The student will be able to describe the task performed by each tool and then accomplish the task.

BLUEPRINT READING

Hours: 60 Credits: 3

A study of blueprint reading skills and basic fundamentals of drafting

COMPUTER LITERACY

Hours: 72 Credits: 4

This introduction to computers will take a brief look at the history of computing, and will emphasize the computer's application to business and industry. Hardware and software concepts will be presented in a hands-on environment. This course is not a programming course, and is available to students with no previous computer background. Offered for majors of programs other than Computer Science Technology.

DEVELOPMENTAL READING AND STUDY SKILLS

Hours: 60 Credits: 0

A study of basic reading and study skills as applied to a basic vocational study including note taking, time control, attitude, attending, summarizing, recognizing definitions and examples, memory training, heading and subheadings, taking essay exams, and reading with speed.

INTRODUCTION TO COMMUNICATIONS

Hours: 48 Credits: 0

An introduction to basic grammar, capitalization, punctuation, and spelling combined with letter format.

BASIC COMMUNICATIONS

Hours: 60 Credits: 0

Prerequisite: Introduction to Communications

Emphasis on grammatical principles, sentence construction and paragraph development.

GENERAL MATH

Hours: 48 Credits: 0

Basic mathematical operations with whole numbers, order of operations, fractions, decimals, tolerance and precision, percentages and reading a ruler.

BASIC MATH MEASUREMENTS

Hours: 24 Credits: 0

Prerequisite: General Math

Ratios and proportions, the metric system, the English system and conversions of metric and English.

INTRODUCTION TO ALGEBRA

Hours: 60 Credits: 0

Prerequisite: General Math

Performing mathematical operations with monomials and polynomials, using scientific notation, and solving and graphing equations.

TRIGONOMETRY I

Hours: 24 Credits: 1

Prerequisite: Introduction to Algebra

Right angle trigonometry, including an introduction to vectors.

INTERMEDIATE ALGEBRA

Hours: 48 Credits: 4

Prerequisite: Introduction to Algebra

A study of relations and functions, polynomials, rational expressions and quadratics, and determinants with an introduction to exponential and logarithmic functions, inequalities, matrices, and sequences and series.

COLLEGE ALGEBRA

Hours: 48 Credits: 4

Prerequisite: Intermediate Algebra

The study of exponential and logarithmic functions, inequalities, determinates and matrices, and sequences and series. The course includes a review of relations and functions, polynomials, factoring, and rational expressions and quadratics.

PLANE TRIGONOMETRY

Hours: 48 Credits: 4

Topics in trigonometric functions, right triangles, trigonometric identities, radian measure, graphs of periodic functions, and oblique triangles.

COMPOSITION I

Hours: 48 Credits: 4

Prerequisite: Introduction to Communications

Principles and techniques of written composition. Emphasis is placed on mechanical proficiency and organizational skills.

TECHNICAL AND BUSINESS WRITING

Hours: 48 Credits: 4

Prerequisite: Composition I

Principles, techniques, and skills needed for college-level scientific, technical, or business writing. Formal elements of reports with library research are emphasized.

INTERPERSONAL COMMUNICATION

Hours: 48 Credits: 4

Theories and exercises in verbal and nonverbal communication with focus on interpersonal relationships.

DISCUSSION AND SMALL GROUP COMMUNICATION

Hours: 48 Credits: 4

Discussion and small group theories and techniques as they relate to group process and interaction.

GENERAL PSYCHOLOGY

Hours: 48 Credits: 4

A survey of the major topics in psychology. Introduces the study of behavior and the factors that determine and affect behavior.

PSYCHOLOGY OF ADJUSTMENT

Hours: 48 Credits: 4

A study of the process involved in the adjustment of individuals to their personal and social environment.

COMPUTER AIDED DRAFTING AND DESIGN I

Hours: 60 Credits: 3

This course is for non-drafting majors. In this course the student will study the fundamental principles of computer aided drafting and how they can aid the drafting and design process. Emphasis will be placed on understanding the procedures of C.A.D. systems by constructing drawings on video terminals and an X-Y plotter.

INTRODUCTION TO LASERS

Hours: 142 Credits: 7

A course designed to introduce the student to the operation of a laser, the properties of light and the emission and absorption of light, and lasing action. This course will also introduce the student to optical cavities, modes of oscillation, temporal and spatial characteristics, laser classifications and characteristics.

TASK LISTING

Identifying Optical Components

1. Describe dielectric coated metal mirror.
2. Describe hot mirror.
3. Describe cold mirror.
4. Describe etalon.
5. Describe retroreflector.
6. Describe wedge.
7. Describe prism.
8. Describe 60 degree prism.
9. Describe right angle prism.
10. Describe penta prism.
11. Describe porro prism.
12. Describe a pellicle.
13. Describe Amici prism.
14. Describe Dove prism.
15. Describe quarter wave plate (zero order and multiple order).
16. Describe half wave plate.
17. Describe thin film polarizer.
18. Describe a flat.
19. Describe Nicol polarizer.
20. Describe Glan Thompson polarizer.
21. Describe Rochan prism polarizer.
22. Describe Wollastin prism polarizer.
23. Describe positive lens.
24. Describe negative lens.

25. Describe window.
26. Describe aspherical optics.
27. Describe meniscus lens.
28. Describe parabolic lens.
29. Describe beamsplitter.
30. Describe Diffraction Grating.
31. Describe Holographic Optical Components.
32. Describe optical isolator.

Identify Optical Devices

1. Describe and use a collimator. (To focus, measure angles, flatness, parallelism, etc.)
2. Describe and use an autocollimator.
3. Describe and use a beam expander.
4. Describe and use a telescope.
5. Describe and use an interferometer.
6. Describe and use a spectrophotometer.
7. Describe and use a microscope.
8. Describe and use a spherometer.
9. Describe and use a spatial filter.
10. Describe and use a monochromator.

Using Geometric Optics

1. State the laws of reflection.
2. Define light ray.
3. Verify the law of reflection by experimentation.
4. Define absolute index of refraction.
5. Define relative index of refraction.

6. Explain the law of refraction.
7. Use Snell's law.
8. Calculate and measure the critical angle of a material.
9. Calculate and measure light beam displacement in a glass plate.
10. Compute the index of refraction of a prism given its apex angle and the minimum deviation angle.
11. Explain and measure color dispersion of light.
12. Apply Snell's law to plane refracting surfaces.
13. Apply Snell's law to spherical refracting surfaces.
14. Draw ray traces of plane refracting surfaces.
15. Draw ray traces of spherical refracting surfaces.
16. Use matrix solutions of multiple lens problems.
17. Define and calculate Brewster's Angle.
18. Describe the effect of an F-stop.
19. Use computers to analyze optics problems.

Preparing Substrate:

1. Inspect material for defects.
(Certify proper material)
2. Select cutter (wire or wheel).
3. Cut blanks.
4. Align crystal axis.
5. Clean substrate.

Lapping Substrate:

1. Calibrate lapping machine.
2. Set lapping pressure.
3. Select lapping head.
4. Select abrasive.
5. Calculate lapping time and application time of abrasive.
6. Lapping of flats, lenses, prisms, laser rods and wedges.
7. Inspection of lapped material to specs.

Polishing Substrate:

1. Calibrate polishing machine.
2. Select polishing compound.
3. Set pressure.
4. Polishing of flats, lenses, prisms, laser rods and wedges.
5. Inspection to specs.

Performing First Echelon Preventive Maintenance:

1. Inspect all mechanical parts of grinder, lapper and polisher.
2. Inspect power supply.
3. Inspect vacuum system.
4. Inspect polishing and lapping plates.

Performing Optical Testing:

1. Use a Twyman-Green interferometer.
2. Use a Fizeau interferometer.
3. Identify aberrations.
 - a. coma
 - b. spherical aberration
 - c. medial focus
 - d. sagittal focus
 - e. astigmatism
 - f. focal shift
 - g. tilt
 - h. combined aberrations
 - i. chromatic aberrations
4. Interpretation of interferograms.
 - a. thru-put irregularities
 - b. peak to valley
 - c. RMS values
5. Use autocollimator.
6. Use focusing telescope.
7. Use shearing plate.
8. Measure flatness and radii using test plates.
9. Measure transmitted wave front distortion.

10. Use a Ronche tester.
11. Use a Foucault tester.
12. Use a Hartman tester.

Performing Visual Inspection by MIL SPEC:

1. Inspect for scratch and dig.
2. Test parallelism of plane optical surfaces.
3. Measure surfaces with profilometer.
4. Measure angular error of prisms.
5. Measure radius of curvature of lenses.
6. Mechanical optics specs (diameter, thickness, [edge and center] clear aperture concentricity).

Explain Wave Optics:

1. Describe and differentiate between photometry and radiometry.
2. Explain the wave nature of light.
3. Differentiate between geometric and wave optics.
4. Explain Huygen's Principle.
5. Draw the refracted and the reflected wave fronts at air-glass interface using Huygen's Principle.
6. Convert light energy units from ev to Joules to wave numbers.
7. Demonstrate how wave optics (Huygen's Principle) are in agreement with geometric optics predictions.
8. State with qualifying conditions the law of reflection and the law of refraction.
9. Describe Fresnel reflections.
10. Calculate the percentage of light reflected from a dielectric surface at almost normal incidence.

11. Show how the reflection of light from a dielectric coating is dependent upon the polarization of the light and the angle of incidence.
12. Describe scattering mechanisms. (Rayleigh, Mie, diffraction.)
13. Describe the superposition principle.
14. Explain the principle of interference.
15. Explain AR and HR dielectric coatings by using interference principles.
16. Use Newton's Ring theory to determine surface defects on lenses.
17. Explain diffraction.
18. Distinguish between Fraunhofer and Fresnel diffraction.
19. Describe "diffraction limited" optics.
20. Describe chromatic aberrations.
21. Describe spherical aberrations.
22. State and use the Law of Malus.
23. Describe linear, circular, elliptical polarization of light.
24. Determine the state of polarization of light.

PRECISION OPTICS TECHNOLOGY
EQUIPMENT LIST

2 ea.	Polishing Machines 6 spindle, 6" capacity	\$36,000
2 ea.	Radius Generators	\$60,000
2 ea.	Precision Centering and Edging Machines	\$60,000
2 ea.	Alignment Drill Press	\$ 1,000
2 ea.	250°F Hot Plates	\$ 500
2 ea.	Cut-off Saws	\$ 5,000
2 ea.	Hand finishing, Pedal Operated, Machine	\$ 6,000
2 ea.	Hand Grinding Machine	\$ 8,000
2 ea.	Master radius test plate set	\$ 5,000
12 ea.	Grinders	\$ 700
12 ea.	Polishers	\$ 700
12 ea.	Correctors	\$ 700
12 ea.	Multiple Blockers	\$ 700

Diamond Wheels

2 ea.	Edging machine wheel	\$ 1,400
2 ea.	Multiple generation wheel	\$ 1,600
2 ea.	Cut-off Saw	\$ 500

Machine Adaptors

2 ea.	Six spindle grinder/polisher	\$ 600
2 ea.	Edger	\$ 400
2 ea.	Generator	\$ 500
2 ea.	Hand Polisher	\$ 150
2 ea.	Hand Grinder	\$ 150
2 ea.	Cut-off Saw	\$ 500

Initial Supplies

Grinding Emery	\$ 1,000
Polishing Compound	\$ 1,000
Machine Coolant	\$ 500
Solvents	\$ 1,500
Diapers	\$ 500
Trays and Containers	\$ 500
Brushes	\$ 250
Polishing Pitch	\$ 2,000
Blocking Pitch	\$ 1,000
Gloves	\$ 1,000
Glass Blanks	\$ 2,000

Test Equipment

Micrometers	\$ 1,000
Spherometers	\$ 1,000
Microscopes	\$ 1,200
Scales	\$ 200
Miscellaneous	<u>\$ 2,000</u>
	\$206,750